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DE 019848547 A1 US 4093355 A

(58) Field of Search
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INT CL[7] G02F 1/133 1/1347
Online: WPI, EPODOC, PAJ

(54) Abstract Title
Two-layer super-twisted nematic liquid crystal display element

(57) A two-layer type STN liquid crystal display element comprising a displaying liquid crystal element 10 with display electrodes 13 formed therein and a compensating liquid crystal element 20. The compensating liquid crystal element 20 comprises opposed glass substrates 25, 26 having transparent resistance films 43, 44 of ITO formed on the entire inner surfaces thereof. The opposite lateral side edges of the transparent resistance films 43, 44 are parallel connected in a short-circuited manner by short-circuiting members 28, and heater electrodes 27 are formed on the transparent resistance film at the opposite lateral side edges.

FIG. 1B

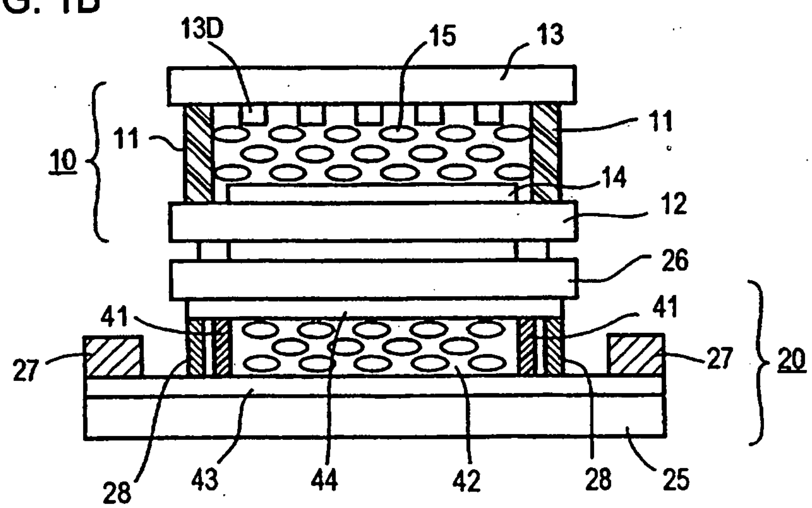

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FIG. 1A

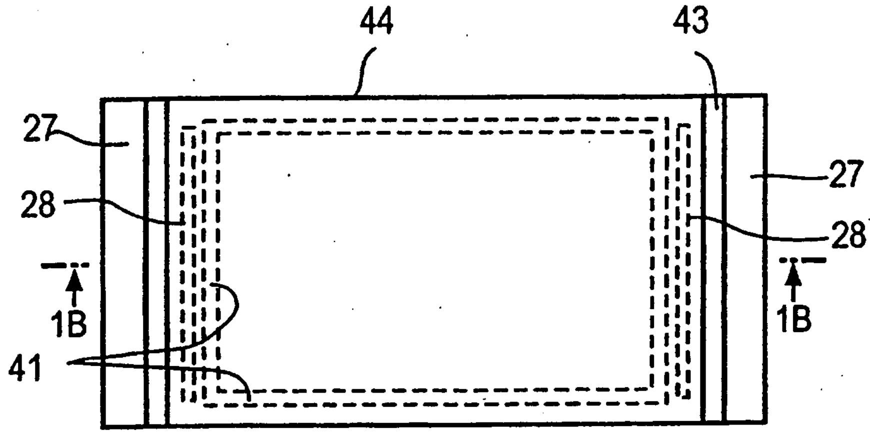

44
43
27
27
28
28
1B
1B
41

FIG. 1B

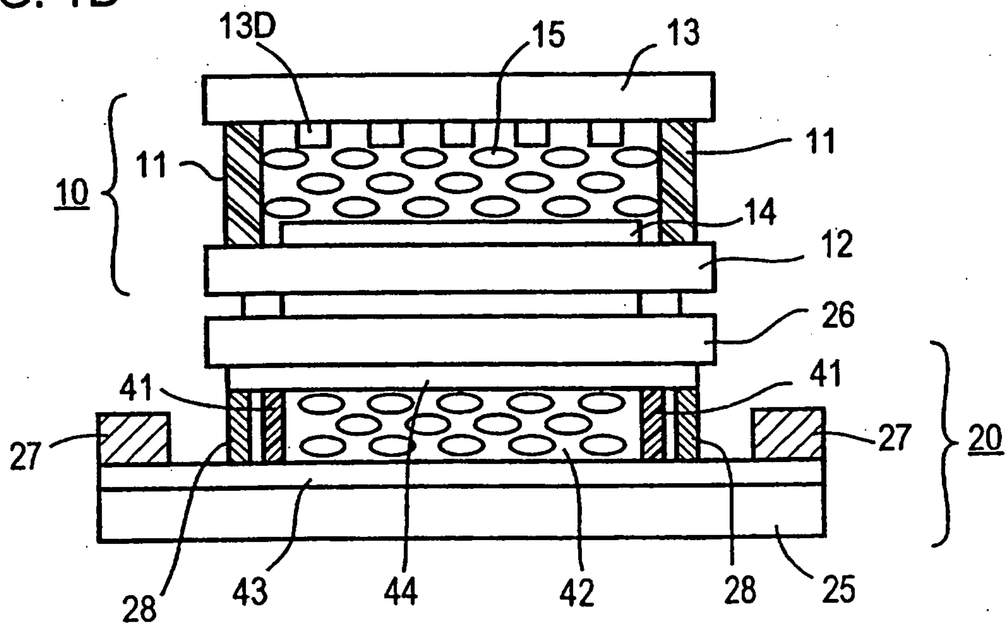

13D
15
13
10
11
11
14
12
26
41
41
27
27
20
28
43
44
42
28
25

FIG. 2A

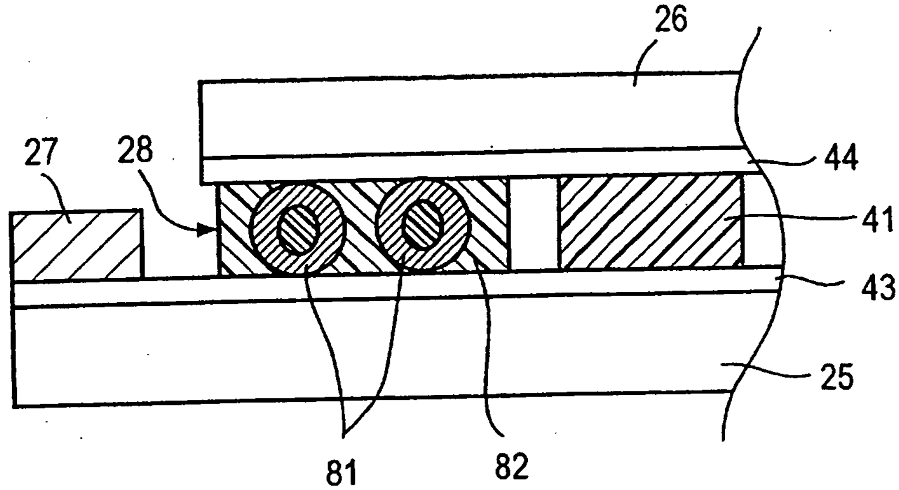


FIG. 2B

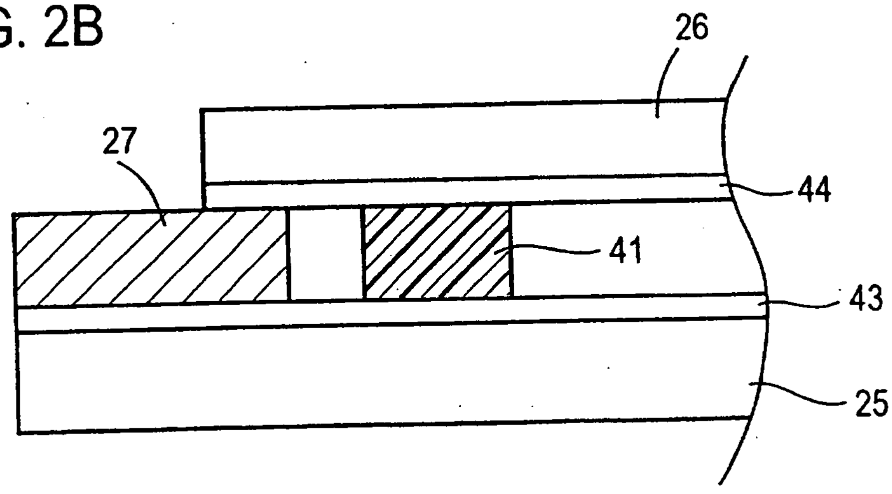


FIG. 3A

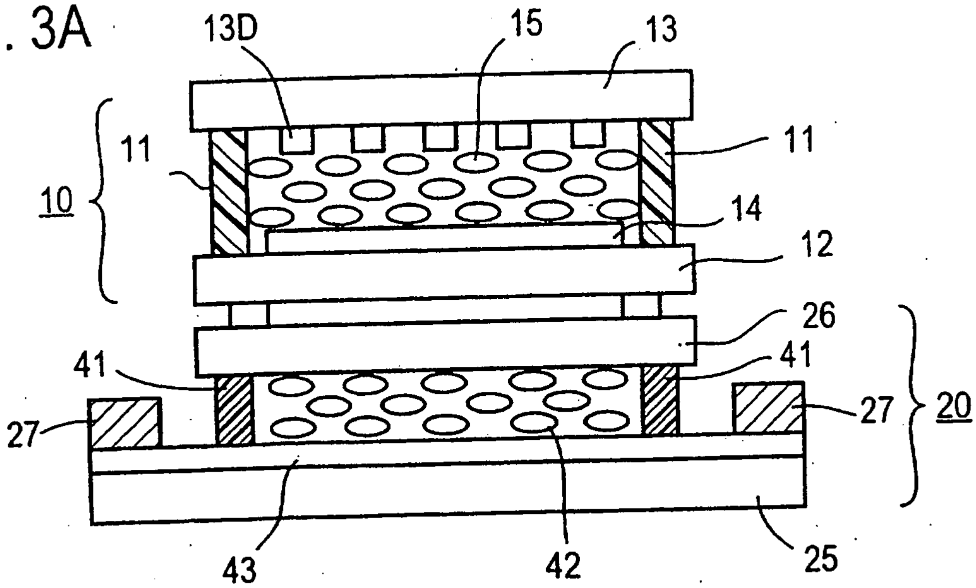


FIG. 3B

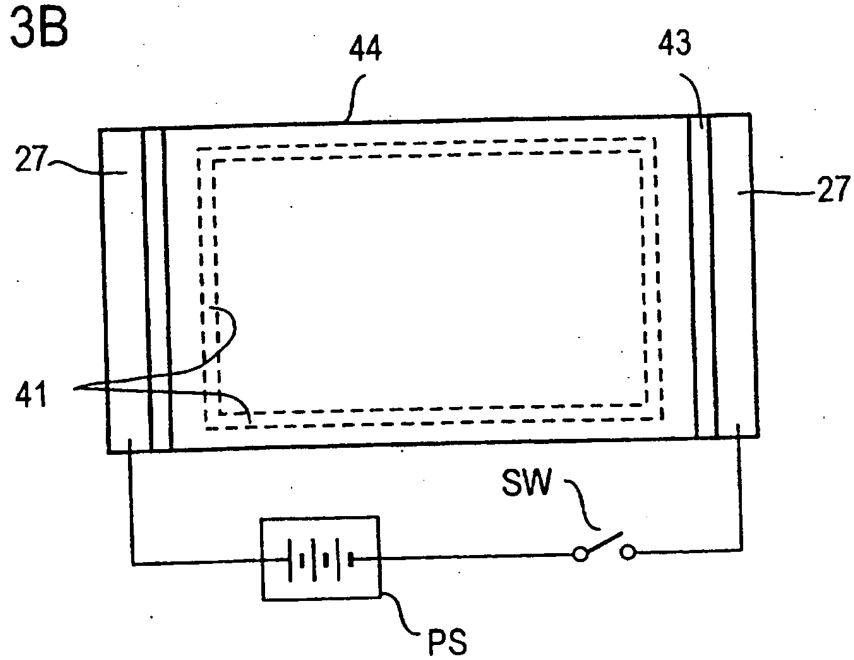


FIG. 4

A

B

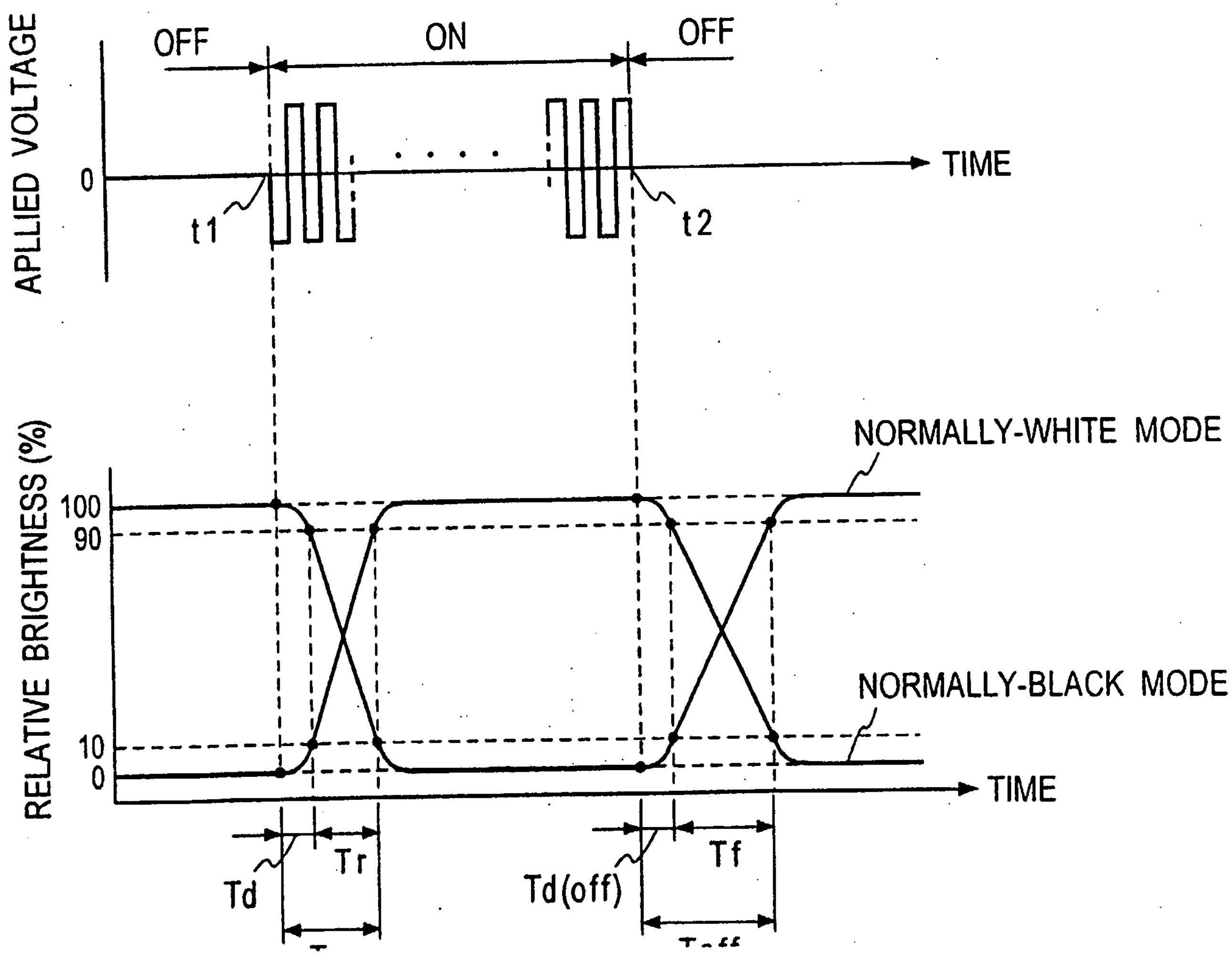
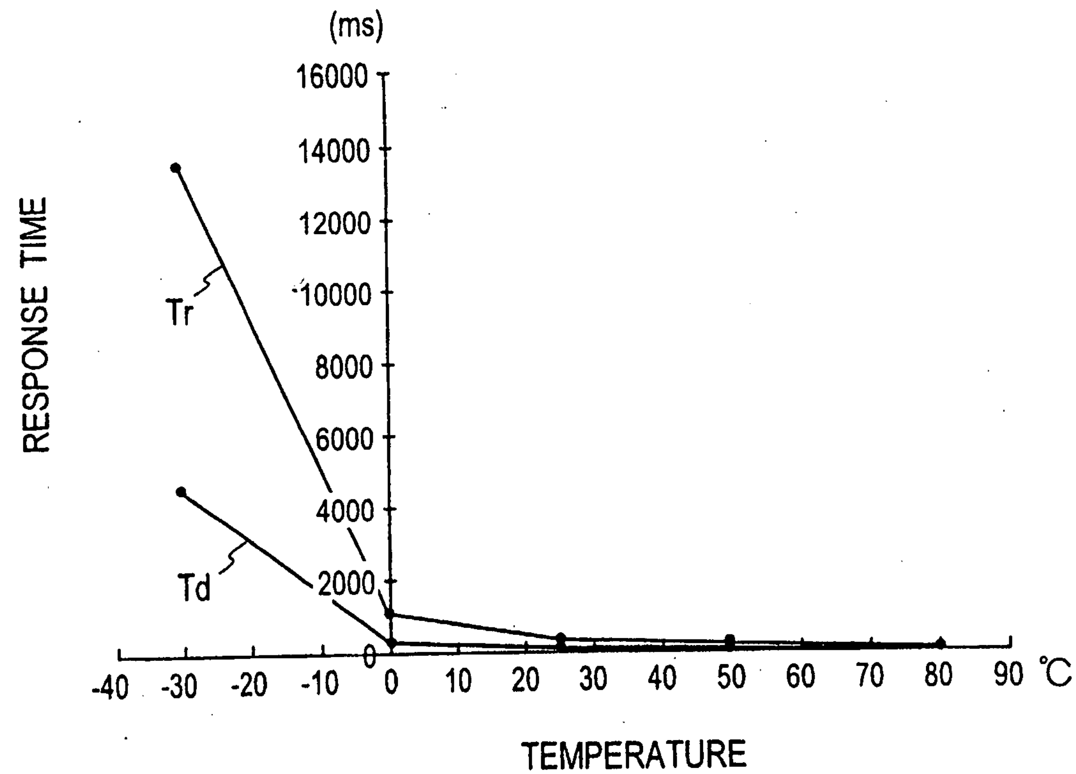

APLLIED VOLTAGE
OFF
ON
OFF
0
TIME
t1
t2
RELATIVE BRIGHTNESS (%)
100
90
10
0
NORMALLY-WHITE MODE
NORMALLY-BLACK MODE
TIME
Td
Tr
Td(off)
Tf

FIG. 5


(ms)
16000
14000
12000
10000
8000
6000
4000
2000
0
RESPONSE TIME
Tr
Td
-40
-30
-20
-10
0
10
20
30
40
50
60
70
80
90 ℃
TEMPERATURE

TWO-LAYER SUPER-TWISTED NEMATIC LIQUID CRYSTAL DISPLAY ELEMENT

BACKGROUND OF THE INVENTION

This invention relates to the two-layer super-twisted nematic (STN) system liquid crystal display element and, particularly to the two-layer type STN system liquid crystal display element having transparent resistance films for a heater formed on substrates.

Fig 3A illustrates the prior art two-layer super-twisted nematic liquid crystal display element disclosed in the PCT application publication WO99/06885 in a form somewhat modified for the benefit of illustration. The two-layer super-twisted nematic (STN) system liquid crystal display element includes a displaying liquid crystal element 10 comprising an STN type liquid crystal 15 contained and sealed with a seal 11 in a gap defined between two spaced glass substrates 12 and 13, and a compensating liquid crystal 20 comprising an STN liquid crystal 42 contained and sealed with a seal 41 in a gap defined between two spaced glass substrates 25 and 26, the displaying liquid crystal element 10 and the compensating liquid crystal 20 being superposed one on the other. The direction of twist of STN type liquid crystal 15 of the displaying liquid crystal element 10 and that of the STN liquid crystal 42 of the compensating liquid crystal 20 are opposite to each other whereby any optical phase difference that may generate in the displaying liquid crystal element 10 may be compensated for by the compensating liquid crystal 20.

First, the temperature-dependent characteristics of the response time of the two-layer STN system liquid crystal display element will be explained with

reference to Figs. 4 and 5. As shown in Fig. 4 (a), if a rectangular wave of voltage V having a constant amplitude is applied at a point in time $t = t_1$ and the applied voltage is zeroed at a point in time $t = t_2$, the relative brightness of the displaying liquid crystal element 10 will vary as shown in curves NW for the normally white mode and in curves NB for the normally black mode in Fig. 4 (b). In this drawing, Td and Td (off) represent the delay time; Tr the rise time; Tf the fall time; Ton = Td + Tr the ON time; and Toff = Td(off) + Tf the OFF time.

It should be noted here that the viscosity of liquid will generally change with varying temperatures. Particularly the liquid crystal, which has both the property of solid and the property of liquid, is subject to striking change in its viscosity due to the temperature variation and the response time of liquid crystal depends on temperature. Fig. 5 illustrates an example of the dependence of the rise time Tr and the delay time Td. When the temperature falls below 0 °C, the delay time Td and the rise time Tr become extremely slow with the resulting rise in the viscosity, and hence the ON time Ton = Td + Tr becomes extremely slow. At a low temperature around -30°C, the two-layer type STN system liquid crystal display element will be too slow in the ON time Ton to be practically useful. This is also true with respect to the OFF time Toff = Td(off) + Tf. The increase in the response time at such low temperatures is more prominent for display elements having higher contrast, which is said to be a drawback to the high-contrast liquid crystal display element like the vehicle-installed liquid crystal panels.

For this reason, in the aforesaid PCT application publication, it is shown that either one (glass substrate 25, for example) of the glass substrates 25 and 26

comprising the compensating liquid crystal 20 has a transparent resistance film 43 formed on the inner surface thereof such that the transparent resistance film 43 on the glass substrate 25 may have electric current passed thereto as required so as to serve as an electric heater. An ITO (Indium Tin Oxide) thin film is typically used for the transparent resistance film 43. For example, as shown assumedly in Fig. 3B, on the opposed left and right side extensions of the glass substrate 25, electric heater electrodes 27 are formed so as to overlie the transparent resistance film 43 and a power source PS is connected between the heater electrodes 27 by means of a switch SW. The use of the transparent resistance film 43 as an electric heater allows for preventing a significant fall in the interior temperature of the two-layer STN system liquid crystal display element.

The liquid crystal display element used as a vehicle-installed indicator is supplied with electric power from a battery. However, the battery voltage V_B of the vehicle is generally as low as 12V. On the other hand, it is difficult to reduce the resistance R provided by the transparent resistance films of ITO to below 20-30Ω. Consequently, if R = 20Ω, for example, the heater power W_H obtained would be only on the order of $W_H = V_B^2/R = 7W$. For this reason, in the extreme cold climate, it may be impossible to raise the temperature of the liquid crystal display element to a degree sufficient to provide a satisfactory response rate.

Although it is not for the purpose of heating liquid crystal, the Japanese Patent Application Publication 2-96716 teaches preventing potential difference distribution due to static electricity from occurring over the liquid crystal by forming transparent resistance films on the inner surfaces of two glass

substrates of a compensating liquid crystal element, dispersing nickel-plated minute plastic ball spacers over the entire surfaces of the glass substrates between the transparent electrodes, and short-circuiting the transparent electrodes of the two glass substrates with each other. However, it is not suggested that the transparent electrodes of the two glass substrates be employed as a heater.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide a two-layer type STN liquid crystal display element having a transparent resistance film heater which is capable of outputting a large electric power at a relatively low voltage for the heater power.

According to this invention, a two-layer type STN system liquid crystal display element is provided which comprises:

a displaying liquid crystal element having transparent display electrodes formed therein and an STN liquid crystal sealed therein and a compensating liquid crystal element superposed on the displaying liquid crystal element and having optically compensating relation with the displaying liquid crystal element, the compensating liquid crystal element including:

two opposed and spaced glass substrates each having transparent resistance films of ITO formed as a heater on their inner surfaces and an STN liquid crystal sealed therebetween, the opposite lateral side edges of one of the glass substrates extending outwardly beyond the corresponding opposite lateral side edges of the other of the glass substrates,

short-circuiting members for electrically short-circuiting and connecting the opposite lateral side edges of the transparent resistance films of the two glass substrates in parallel with each other, and

heater electrodes formed on the transparent resistance film of the one glass substrate at the opposite lateral side edges in the regions extending outwardly beyond the corresponding opposite lateral side edges of the other glass substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described by way of example only, with reference to the accompanying drawings in which:-

Fig. 1A is a plan view illustrating one embodiment of this invention;

Fig. 1B is a cross-sectional view taken on line 1B-1B of Fig. 1A;

Fig. 2A is a detailed cross-sectional view of a part of Fig. 1B illustrating one embodiment of the transparent resistance film short-circuiting member;

Fig. 2B is a detailed cross-sectional view of a part of Fig. 1B illustrating another embodiment of the transparent resistance film short-circuiting member;

Fig. 3A is a cross-sectional view illustrating an example of the prior art; and

Fig. 3B is an assumed plan view of the example of the prior art;

Fig. 4. is a diagram illustrating the operation of the liquid crystal display element; and

Fig. 5 is a diagram illustrating the temperature-dependent characteristics of the response time of the liquid crystal display element.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment of this invention will now be described with reference to Fig. 1. As in the prior art example shown in Fig. 3, one glass substrate 12 of the displaying liquid crystal element 10 has transparent display electrodes 13D preformed on the inner surface thereof. The other glass substrate 13 has a

transparent common electrode 14 preformed on the entire inner surface thereof. An STN type liquid crystal 15 is contained and sealed with a main seal member 11 in a gap defined between the two spaced glass substrates 12 and 13.

One glass substrate 25 of the compensating liquid crystal 20 has a transparent resistance film 43 of ITO preformed entirely on one side surface thereof. In this embodiment of the invention, the other glass substrate 26 also has a transparent resistance film 44 of ITO preformed entirely on the inner surface thereof. An STN liquid crystal 42 is contained and sealed with a seal 41 in a gap defined between the transparent resistance film 43 of the glass substrate 25 and the transparent resistance film 44 of the glass substrate 26, the STN liquid crystal 42 being twisted in a direction opposite from the direction of twist of the STN type liquid crystal 15 filled in the displaying liquid crystal element 10. This displaying liquid crystal element 10 and the compensating liquid crystal 20 have an optically compensating relationship with each other, as in the prior art shown in Fig. 3.
The substrate 25 has its opposite lateral side edges extending beyond the lateral side edges of the substrate 26, and in the outer extension regions, heater electrodes 27 each comprising a layer of electrically conductive material are formed on the transparent resistance film 43 so as to extend along the lateral side edges of the substrate 25. The two transparent resistance films 43 and 44 are connected in parallel with each other by short-circuiting the opposite lateral side edges of the transparent resistance film 44 of the substrate 26 with the transparent resistance film 43 of the substrate 25 by means of short-circuiting conductor members 28 outside of the seal member 41. The short-circuiting conductor members 28 are formed so as to

extend parallel to the heater electrodes 27.

In order to ensure a uniform profile of temperature due to the heat produced by the transparent resistance films 43, 44, it is preferable that the potential gradients of the transparent resistance films 43, 44 adjacent their opposite lateral side edges along the heater electrodes 27 be minimized. To this end, it is preferable that the resistance R_0 of the heater electrodes 27 be small as compared to the resistance R of the parallel-connected transparent resistance films 43, 44 such that the condition $R_0 \leq R/15$ may be met, for example. For the heater electrodes 27, plated or vapor deposited film of Ni/AU, or plating of Ni/solder, or vapor deposited film of copper/Ni, for example may be used. Alternatively, electrically conductive paste such as silver paste may be used.

The transparent resistance films 43 and 44 of the substrates 25 and 26 connected in parallel by means of the short-circuiting conductor members 28 are connected through the two heater electrodes 27 to the common external power source PS so that the resistance films may be heated by passage of electric current therethrough. As can be appreciated, the heat generated by the transparent resistance films 43 and 44 provides for preventing an excessive drop in the internal temperature of the two-layer STN system liquid crystal display element.

As described above, since the transparent resistance films 43 and 44 are in parallel connection and are connected to the common power source, the two transparent resistance films are at substantially the same potential. Consequently, the liquid crystal between two transparent resistance films is prevented from being driven. Further, because of the parallel connection of the transparent resistance films, the parallel resistance is smaller than a single

one of the transparent resistance films. As a result, the amount of heat liberated by the films is increased, and the heating efficiency is enhanced. Although it is necessary to select and employ transparent resistance films of low resistance, it is difficult to form a transparent resistance film having a resistance less than 10Ω from ITO material. In view of this, according to this invention, transparent resistance films are formed on two glass substrates and those two transparent resistance films are connected in parallel to reduce the parallel resultant resistance to thereby enhance the heating efficiency.

Now referring to Fig. 2A, the detailed features around the left and right opposed lateral side edges of the compensating liquid crystal element will be described. The short-circuiting members 28 each comprise spacers 81 having metal coatings applied to the surfaces thereof, and adhesives 82 electrically and mechanically bonding and securing the spacers 81 between the transparent resistance film 43 and the transparent resistance film 44 outside of the seal member 41.

Fig. 2B illustrates an alternative embodiment in which instead of using the short-circuiting members 28, the heater electrodes 27 are adapted to double as the short-circuiting members. In this case, the two heater electrodes 27 formed on the transparent resistance film 43 so as to extend along the opposite left and right lateral side edges of the substrate 25 are expanded in their width to extend into the gap defined between the transparent resistance film 43 of the glass substrate 25 and the transparent resistance film 44 of the glass substrate 26 to thereby double as short-circuiting members, whereby the short-circuiting arrangement is simplified. That is, the conductive material for forming the heater electrodes 27 is spread to fill the gap defined between

the transparent resistance film 43 of the glass substrate 25 and the transparent resistance film 44 of the glass substrate 26 to thereby form the short-circuiting members as well as the heater electrodes. By using silver paste as a material for forming the heater electrodes 27, the heater electrodes 27 and the short-circuiting members 28 may be simultaneously formed.

THE EFFECTS OF THE INVENTION

As discussed above, according to this invention, the heat generation may be enhanced even at a low voltage of power source by parallel connecting the transparent resistance films formed on the inner surface of two glass substrates comprising a compensating liquid crystal element and passing electrical current through the films for heating. In addition, the short-circuiting structure may be simplified by forming the heater electrodes 27 so as to extend into the gap defined between the transparent resistance film 43 of the glass substrate 25 and the transparent resistance film 44 of the glass substrate 26 to thereby double as short-circuiting members.

CLAIMS

1. A two-layer type super-twisted nematic liquid crystal display element comprising a displaying liquid crystal element having transparent display electrodes formed therein and an STN liquid crystal sealed therein and a compensating liquid crystal element superposed on said displaying liquid crystal element and having optically compensating relation with the displaying liquid crystal element, said compensating liquid crystal element including:

two opposed and spaced glass substrates each having transparent resistance films of ITO formed as a heater on their inner surfaces and an STN liquid crystal sealed therebetween, the opposite lateral side edges of one of the glass substrates extending outwardly beyond the corresponding opposite lateral side edges of the other of the glass substrates,

short-circuiting members for electrically short-circuiting and connecting the opposite lateral side edges of the transparent resistance films of said two glass substrates in parallel with each other, and

heater electrodes formed on the transparent resistance film of said one glass substrate at the opposite lateral side edges in the regions extending outwardly beyond the corresponding opposite lateral side edges of said other glass substrate.

2. The two-layer type super-twisted nematic liquid crystal display element of claim 1, wherein said two opposed and spaced glass substrates comprising said compensating liquid crystal element are bonded together by a main seal member to seal a gap between the glass substrates, said short-circuiting members being formed so as to extend parallel to said heater electrodes.

3. The two-layer type super-twisted nematic liquid crystal display element of claim 1 or 2, wherein said short-circuiting members each comprise spacers having metal coatings applied to the surfaces thereof, and adhesives electrically and mechanically bonding and securing said spacers between said two transparent resistance films.

4. The two-layer type super-twisted nematic liquid crystal display element of claim 1 or 2, wherein said heater electrodes are formed so as to extend into the gap defined between said two transparent resistance films to thereby double as said short-circuiting members.

5. The two-layer type super-twisted nematic liquid crystal display element of any preceding claim, wherein the resistance R_0 of said heater electrodes is set with respect to the resistance R of said parallel-connected transparent resistance films at such value that meets the condition $R_0 \leq R/15$.

6. The two-layer type super-twisted nematic liquid crystal display element of any preceding claim, wherein said heater electrodes comprise films of Ni/AU formed on said transparent resistance film.

7. The two-layer type super-twisted nematic liquid crystal display element of any one of claims 1 to 5, wherein said heater electrodes comprise films of Ni/Cu formed on said transparent resistance film.

8. The two-layer type super-twisted nematic liquid crystal display element of any one of claims 1 to 5, wherein said heater electrodes comprise films of Ni/solder formed on said transparent resistance film.

9. A two-layer type super-twisted nematic liquid crystal display element substantially as hereinbefore described with reference to any of figures 1A to 2B.

10. A liquid crystal display device which incorporates a two-layer type super-twisted nematic liquid crystal display element as claimed in any one of claims 1 to 9.

The Patent Office

INVESTOR IN PEOPLE

Application No: GB 0101543.7 13

Claims searched: 1 to 10

Examiner: Jane Croucher

Date of search: 26 July 2001

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): G2F (FCD, F25F)

Int Cl (Ed.7): G02F (1/133, 1/1347)

Other: Online: WPI, EPODOC, PAJ

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	US 4093355 A KAPLIT (see whole document)	1 at least
X	DE 19848547 A1 (MANNESMANN) published 12.05.99 (see WPI abstract accession no. 99-279602/24 and whole document)	1 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		